

A Neurobiological Perspective on Early Human Deprivation

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This paper was made possible in part by grants from the NIH (MH078829 to Charles A. Nelson; MH068857 to Megan Gunnar). For information about this article, direct queries to the author at the Developmental Medicine Laboratory of Cognitive Neuroscience, Children's Hospital Boston, Harvard Medical School, 1 Autumn Street, Mailbox #713, Office AU621, Boston, MA 02215-5365 ; e-mail : charles.nelson@childrens.harvard.edu.

Paper accepted for publication in *Child Development Perspectives*, Vol. 1. Number 1 © Society for Research in Child Development, and reprinted by permission from the Society for Research in Child Development and Blackwell Publishing.

Abstract

The number of children who are abandoned or orphaned around the world is rapidly increasing owing to war, AIDS, and poverty. Many of these children are placed in institutional settings for lack of individual or societal resources or because of long-standing cultural traditions. It has been known for over half a century that rearing children in institutional care characterized by profound sensory, cognitive, linguistic, and psychosocial deprivation can be deleterious to their development. This paper examines the neural mechanisms that likely underlie the maldevelopment many institutionalized children experience.

An extraordinary number of children throughout the world begin their lives in psychologically adverse circumstances. In some cases, these children live with their parents in profound poverty; in others, they either do not have parents (such as those orphaned by war or AIDS) or they are abandoned by their parents. Vast numbers of abandoned or orphaned children living in Eastern Europe, China, and Latin American live in institutional settings. This article describes the effects of profound early deprivation (common in many institutional settings) on brain and behavioral development.

The Nature of the Problem

UNICEF estimates that approximately 1.5 million children in Central and Eastern Europe live in public care (orphanages, group homes, psychiatric units). These include children who have been abandoned by their parents, whose parents have died, who live in hospitals because of chronic illness (e.g., AIDS), and who live in penal institutions. The European Commission for Social Cohesion estimates that 10–20 per 1,000 children birth to age 18 in Bulgaria, Russia, and Romania, and 5–10 per 1,000 in Poland, Hungary, Moldova, Lithuania, Latvia, and Estonia live in orphanages, group homes, or psychiatric units?¹ In Sweden, Finland, Ireland, Belgium, the Netherlands, Italy, and Spain, 1.5–3.0 per 1,000 children under age 3 are institutionalized (Brownell et al., 2004).

Collectively, institutionalizing young children is a common practice throughout many parts of the world. The majority of these children will remain in such settings for many years, whereas a relatively small minority will be adopted, most internationally.² Indeed, in 2004, nearly 23,000 international adoptions took place in the United States. Not surprisingly given the figures cited above, the vast majority of these children were from Eastern Europe and Asia (Russia and China in particular).

As it does in families, the quality of care varies among institutions; there is also variability in the nature and degree of deprivation. For example, in some model institutions in Russia, the caregiver-child ratio is reasonable, and the degree of sensory, cognitive, and linguistic deprivation is not severe. At the other end of the spectrum, institutional life can be characterized by profound, global deprivation. The ratio of children to caregivers can exceed 15:1; caregivers are generally poorly trained and, in many cases, uncommitted to the welfare of children and unresponsive and insensitive to children's needs. Nutrition can be substandard, cognitive stimulation can be inadequate, and exposure to mature language is frequently lacking owing to a paucity of adult caregivers. Basic sensory stimulation can be lacking across multiple modalities, leading to perceptual deficits (e.g., lack of patterned light stimulation because walls and ceilings are painted white and infants are left in their cribs for long periods of time; infants are not held or touched, leading to tactile deprivation). Finally, institutional care is frequently characterized by strict adherence to conformity

(e.g., children are dressed alike) and regimen (e.g., children all eat at the same time, use the toilet at the same time, etc.). It would not be unreasonable to suggest that life in institutions that globally deprive young children resembles peer-rearing common in some non-human primate studies (e.g., Suomi, 1997). Of course, even this is misleading because non-human primates typically huddle together when left without caregivers, whereas human children typically do not.

Effects of Early Institutionalization on Development

For most of the twentieth century, clinicians and researchers noted the deleterious effects of institutional rearing on the development of young children. Initially, many of these studies were uncontrolled or poorly controlled, but more rigorous, recent investigations have confirmed earlier findings that institutional care is often associated with a variety of deleterious outcomes (for recent review, see Maclean, 2003).

Contemporary research has documented many problems in young children adopted out of institutions in Eastern Europe and Russia. Abnormalities include a variety of serious medical problems (Johnson, 1997; Johnson et al., 1992), physical and brain growth deficiencies (Aronson, Johnson, Melnikova, & Alonso, 1999; Benoit et al., 1996), cognitive problems (Morison, Ames & Chisholm, 1995; Rutter et al., 1998), speech and language delays (Dubrovina et al, 1991; Groze & Ileana, 1996; Albers, Johnson, Hostetter, Iverson & Miller, 1997), sensory integration difficulties and stereotypies (Cermak &

Daunhauer, 1997; Chisholm & Savoie, 1992), as well as social and behavioral abnormalities (Fisher, Ames, Chisholm, & Savoie, 1997; O'Connor, Bredenkamp, & Rutter, 1999). The latter include difficulties with inattention and hyperactivity (Rutter, 1999), disturbances of attachment (Chisholm, Carter, Ames, & Morison, 1995; Chisholm, 1998; O'Connor et al., 1999; O'Connor & Rutter, 2000) and a syndrome that mimics autism (Federici, 1998; Rutter et al., 1999). Some of these abnormalities are associated with risk factors that precede placement in the institutions (e.g., prenatal alcohol exposure), but quality of care is often appalling in these institutions, and many problems seem related to the ecology of institutional life (e.g., Ames, 1997).

Several longitudinal have examined the effects of institutionalization on children's development. Tizard and her colleagues compared four groups of young children who had been reared in institutions in the United Kingdom for the first two to four years of life: a group that was adopted between ages 2 and 4, a group returned to their biological families between age 2 and 4, a group who remained institutionalized, and a group of never-institutionalized children of the same age (see, e.g., Tizard, 1977; Tizard & Hodges, 1978; Tizard & Reese, 1974, 1975). Across all domains, the adopted children fared better than the institutionalized children. Unfortunately, as is the case with virtually all studies of institutionalized children, they were not randomly assigned to the groups, and selection factors may have influenced the findings (that is, more developmentally advanced children may have been the first adopted).

Two longitudinal studies have been conducted recently with children adopted from Romanian institutions. Ames, Chisholm, and colleagues (in Maclean, 2003) included three groups of children adopted by Canadian parents: 1) children adopted after having spent at least eight months in a Romanian institution; 2) children adopted from Romanian institutions at less than 4 months of age; and 3) a Canadian-born (but not adopted) comparison group matched on age and sex to the first group. They found more behavior problems, disturbances of attachment, and lower IQs in the group of children who had spent eight months or more in Romanian institutions (see Maclean, 2003).

O'Connor and Rutter (2000) compared young children adopted from Romania with children adopted within the United Kingdom (see also Rutter et al., 2004). They found that at both age 4 and again at age 6, the duration of deprivation was linearly related to the number of signs of attachment disorders. Children exhibiting indiscriminate sociability at age 6 had experienced deprivation for twice as long as children exhibiting no attachment disorder signs ($M = 22$ months vs. $M = 11$ months). Cognitive recovery was inversely related to age of adoption, although social and emotional problems were less clearly related to timing.

Taken together, these findings suggest that although psychosocial deprivation may be associated with impairment across a range of developmental domains, the degree of impairment and trajectories of recovery may vary. These tentative conclusions must be tempered by the lack of randomization and

potential selection bias in who is adopted, as well as by lack of data on individual differences in institutional experiences and lack of adequate comparison groups (i.e., native children who have never been institutionalized).

Recently, Zeanah, Fox, and Nelson (2003) launched the Bucharest Early Intervention Project (BEIP), in which they examine three cohorts of children: 1) those abandoned at birth, placed in institutions, and who continue to reside in institutions; 2) those abandoned at birth, placed in institutions, and then randomly assigned to foster care; and 3) a sample of children living with their biological parents in the greater Bucharest community. Randomization and the use of an in-country comparison sample circumvents many of the shortcomings of previous studies. Early findings (see Nelson, Zeanah, and Fox, 2007) suggest that institutional care has a profoundly negative effect on physical growth, language, cognitive, social-emotional, and brain development; and that children placed in foster care show improvements in many (although not all) of the domains that are deleteriously affected by institutional life.

The Effects of Early Institutionalization on Brain Development

Given the dramatic behavioral abnormalities observed in institutionalized and formerly institutionalized children, it seems reasonable to consider the neural systems that might be associated with those behavioral abnormalities. Previous research on institutionalized children has not included measures of brain functioning, although some assessments have been conducted with children

adopted from institutions. For example, Chugani and colleagues (2001) used Positron Emission Tomography (PET) in ten children (average age was 8 years) who had been adopted from a Romanian institution. PET employs a radioactive isotope to examine brain metabolism; for example, the brain's use of glucose, a form of energy. Nearly all children had been placed in the institution before age 18 months, and had lived in the institution an average of 38 months before being adopted. Compared with a control group of healthy adults and a group of 10-year-old children with medically refractory epilepsy (i.e., who were still experiencing seizures), the adoptees showed significantly reduced brain metabolism in select regions of the prefrontal cortex and the temporal lobe, regions associated with higher cognitive functions, memory, and emotion (for example, the orbital frontal gyrus, the amygdala and the hippocampus were all affected). Behaviorally, the adopted children suffered from mild neurocognitive impairments, impulsivity, attention and social deficits – behaviors that are consistent with the patterns of brain findings.

More recently, this same group of researchers examined the connectivity of brain regions that are myelinated (so-called “white matter”) in this same sample of previously institutionalized children (see Eluvathingal et al., 2006). The authors found that white matter connectivity was diminished in the *uncinate fasciculus* region of the brain in the early deprivation group compared with controls. Because this structure provides a major pathway of communication between brain areas involved in higher cognitive and emotional function (e.g.,

amygdala and frontal lobe), the authors concluded that connectivity between brain regions is negatively affected by early institutionalization. It is important to note, however, that these children all tested in the normal range of IQ (although their verbal IQ was lower than their performance IQ), and they suffered only mild impairments in a variety of neuropsychological domains (e.g., sustained attention), as they did in the PET study. How the functional anisotropy (FA; an index of myelination) and behavioral data relate to one another is unclear.

Collectively, results from these two studies point to the neurobiological sequelae of early and prolonged institutionalization. In particular, these children suffered from metabolic deficits in the areas of the brain believed to be involved in higher cognition, emotion, and emotion regulation. Unfortunately, because this sample was small and because this study suffers from the same methodological shortcomings as other post-adoption studies noted earlier, the generalizability of these findings may be limited.

Pollak and colleagues (in Wismer Fries et al., 2005) have also examined the effects of early institutionalization on neurobiological systems, although not the brain per se. This group examined oxytocin and vasopressin, two hormones long associated with affiliative and positive social behavior, in a sample of previously institutionalized children. The previously institutionalized children showed lower overall levels of vasopressin than controls. In addition, they showed lower levels of oxytocin after interacting with their caregiver compared with controls.

Collectively, the authors suggest that “a failure to receive species-typical care disrupts the normal development of the [oxytocin and vasopressin] systems in young children” (p. 17239). Unfortunately, because these data were collected several years after adoption, and because no current data on children’s social behavior (such as attachment) were reported, it is difficult to know if the early experiences caused these hormonal changes.

As noted earlier, the BEIP is designed to examine the effects on brain development of early institutionalization that is characterized by profound sensory, cognitive, linguistic, and psychosocial deprivation.³ Because of the age of the children and limitations in the neuroimaging tools available for use in this project, we were limited to recording the electroencephalogram (EEG) and the event-related potential (ERP). The EEG assesses general cortical activity, whereas the ERP reflects the functioning of populations of neurons acting synchronously during a cognitive task, such as face processing, memory, and so forth.

In prior work, we (Marshall et al., 2004) have reported that the institutionalized group had increased levels of low-frequency power and decreased levels of high-frequency power in the EEG compared with the never-institutionalized group. That is, the institutionalized group had less cortical brain activity than the control group (whether subcortical activity is similarly affected is unknown). Similarly, Parker et al. (2005a, b) performed two cognitive manipulations while recording ERPs. In one manipulation, researchers presented children with images of different facial expressions. In another, they

alternated images of the caregiver's face and the face of a stranger. In both cases, the institutionalized population showed reduced amplitude in several ERP components compared with the never-institutionalized group. In all three studies, then, the institutionalized group showed reduced brain activity, a finding that may be consistent with Chugani's PET data.

Collectively, it appears that early institutionalization in severe situations has a profoundly negative effect on brain development – although there is still a paucity of data. Specifically, institutionalization appears to lead to a reduction in cortical brain activity (both metabolically and electrophysiologically) and to dysregulation of neuroendocrine systems that mediate social behavior.

Why Is Institutional Rearing Bad for the Brain?

The initial evidence is compelling that early institutionalization (when characterized by profound sensory, cognitive, linguistic, and psychosocial deprivation) has a negative impact on behavioral development. It is also increasingly clear that some of the deficits and developmental delays that result from such institutional rearing have their origins in compromised brain development. The question I seek to address in this final section is why? To address this question requires that I first summarize what drives brain development.

In brief, postnatal brain development is driven by an interaction of genes and experience. Genes provide for the early specification of structures and

circuits, whereas experience provides the specialization and fine tuning needed to lead to mature function. As has been discussed in a variety of forums (e.g., Nelson, de Haan and Thomas, 2006), brain development reflects a combination of experience-expectant and experience-dependent mechanisms. The former refers to features of the environment that are (or at least, should be) common to all members of the species, whereas the latter refers to features of the environment that are unique to the individual. Thus, having access to patterned light information or a caregiver are features of the environment common to the species, whereas individual differences in environmental challenges (e.g., quality and quantity of stimulation) are unique to the individual.

A short list of experience-expectant features of the environment might include access to a caregiver, adequate nutrition, sensory stimulation (e.g., visual, auditory, tactile), and linguistic input. It likely also includes an environment that is low in so-called “toxic” stress or it provides the building blocks to cope with stress. Of course, if mental and language development is to occur, the environment requires cognitive and linguistic challenges. This list is far from exhaustive, but by inference, it illustrates a key point: many forms of institutional rearing lack most elements of a conducive environment. As a result, the young nervous system, which actively awaits and seeks out environmental input, is robbed of such input. This lack of input leads to underspecification of circuits and the miswiring of circuits. Because children living in institutions lack

input (stimulation) on a grand scale, we should not be surprised that they experience a range of problems due to “errors” in brain development.

There is also another potential consequence of early institutional rearing. Typical brain development is characterized by an initial overproduction of both neurons and synapses, followed by a retraction to adult numbers (which varies by area; for elaboration, see Nelson et al., 2006). It is believed that the process of overproducing neurons and synapses is guided by a genetic program, whereas the retraction process may depend more heavily on experience. If true, then it may be that living in a deprived environment can lead to errors in apoptosis (programmed cell death). In the BEIP study, we have observed two findings consistent with this hypothesis: smaller head size (even among children placed in foster care) and reduced brain activity. These findings may reflect apoptosis gone awry; specifically, that too many neurons or synapses, or both, were retracted. Because most regions of the brain do not make new neurons postnatally, it is possible that early institutional rearing may have a permanent effect on cell and synapse numbers.

Of course, institutional environments vary in the quality and quantity of deprivation. In my experience in Romanian institutions, I have seen considerable variability in quality of caregiving and the quality of sensory, linguistic, and cognitive stimulation. This leads to an important qualifier in modeling the neurobiology of early institutionalization: some domains of function are more experience-dependent than others, and domains vary in *when* experience is

required to facilitate a typical developmental trajectory. Thus, the long-term development of children with histories of early institutionalization will depend on a) at what age they were institutionalized, b) how long they were institutionalized, and c) the exact features of the environment. Moreover, these three dimensions must be set against a backdrop of a child's genetic makeup and his or her prenatal experience (e.g., was the mother adequately nourished? Was the fetus exposed to alcohol or other teratogens?). Unfortunately these last two dimensions are rarely known in most studies of post-institutionalized children because genetic information was not obtained and because no reports exist about prenatal development. However, the combination of these three factors – prenatal experience, postnatal experience, and genetic makeup – likely lead to developmental programming effects that may well set the stage for years to come (see Rutter et al., 2004, for elaboration).

Implications

There are many implications of this research. For example, many children living throughout the world (including North America) experience deprivation owing to neglectful parents. Although perhaps not quite as severe as the conditions in many institutions, these children still experience profound neglect. There is an urgent need for societies to respond to the needs of such children, and doing so may be informed by the results of this research

A second implication of this work applies to the child protection systems in much of this world. We know the longer a child lives under adversity, the more that child is at risk and the more difficult it will be to redirect that child's development along a typical trajectory. Most child protection systems, however, pay little heed to this clear evidence, and fail to move children into permanent homes more quickly, or to remove them from abusive homes sooner.

Finally, the lessons learned from the BEIP should be noted by the many countries engaged in war or ravaged by disease. Thus, how the world will handle the thousands of children currently being orphaned in Africa, Afghanistan, and Iraq is unclear, although it is frequently the impulse of such countries (motivated by financial, cultural or practical forces) to place such children in institutional settings rather than to develop a high-quality foster care or adoption system. Finally, the lessons learned from the BEIP should be noted by the many countries engaged in war or ravaged by disease. Thus, how the world will handle the thousands of children currently being orphaned in Africa, Afghanistan, and Iraq is unclear, although it is frequently the impulse of such countries (motivated by financial, cultural or practical forces) to place such children in institutional settings rather than to develop a high-quality foster care or adoption system. Wasil Noor, Deputy Minister of Social Welfare in Afghanistan, estimates that of the 1.6 million orphaned Afghani children, more than 10,000 are living in institutional care . Approximately 85% of these children, he estimates, have surviving parents (often both). The government has recently

launched a deinstitutionalization program, reunifying children with their families, and providing income generating support. ⁴

Overall, we have known for more than half a century that children reared in awful institutions are at great risk for atypical development. Most of this work has been descriptive in nature, with little elucidation of the biological mechanisms responsible for maldevelopment. Advances in neuroscience now make it possible to elucidate why, from a neurobiological perspective, children reared in certain institutions are at risk. Having laid the groundwork for a more mechanistic approach to understanding the effects of such early adversity on development, the next step will be to develop interventions targeted at the neural circuits that have been altered by institutional life, with the ultimate goal to use the science of early development to change the policies countries adopt to address their abandoned or neglected children.

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¹ Although Romania has made great strides in reducing the number of children living in institutions – from over 100,000 a decade ago to 30,000 today – the number of children being abandoned has actually held steady at approximately 8,000/year.

² Again, using Romania as an example, since there is a moratorium on international adoption and since domestic adoption remains uncommon, abandoned children typically remain in institutions or, more recently, are placed in state-run foster care or are reunited with their biological parents (although the child protection system in Romania generally does an inadequate job of supporting foster care or policing reunification).

³ It is worth noting that in the data reported to date, an intent to treat design was adopted; thus, not all children relegated to the institutionalized group are currently living in institutions – some have been reunited with their biological families and others have been placed in state run foster care. Thus, our findings should be considered conservative.

⁴ Personal communication with Aaron L. Greenberg, Coordinator, Better Care

Network UNICEF / Child Protection Section, New York, May 15, 2007.